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Decision support model for the control of Anthonomus weevils (Curculionidae) in pome fruit

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Abstract

In recent years, weevils have emerged as significant pests in pome fruit cultivation across Belgium, posing considerable challenges to apple and pear growers. The apple blossom weevil (Anthonomus pomorum), pear bud weevil (Anthonomus pyri), and pear blossom weevil (Anthonomus spilotus), previously considered secondary pests, have surged in prevalence and impact.

This study uses historical climatic and monitoring data to calculate degree-day accumulations and develop a phenological prediction model. The model forecasts adult emergence, egg and larval development, and supports optimal timing for monitoring pest thresholds and applying insecticidal or cultural controls. A temperature driven model forecasting the dynamics of the subsequent life stages of A. pomorum combined with local weather forecasts gives growers a reliable decision support for the control of A. pomorum.

Keywords: *Anthonomus pomorum*, apple blossom weevil, phenology prediction model, degree-day

Introduction

The adult apple blossom weevil, *Anthonomus pomorum* (L.) (Coleoptera: Curculionidae), is increasing in importance as a pest. Since several insecticide active ingredients are no longer registered, the control of *A. pomorum* is difficult and more fruit losses are reported by Belgian growers. *A. pomorum* has only one generation each year. From summer to the end of winter of the following year, adult weevils are in aestivohibernation. That time, they hide or within the apple orchard they damaged, or in an adjacent orchard or forest (Troitzky, 1928; Wiesmann, 1928; Brown et al., 1993; Toepfer, 2000).

Field observations from late winter to early spring indicate that as soon as temperature thresholds are reached and sepals move and the light-colored zones become visible (BBCH 53) (own observations), adult weevils start feeding on flower buds. After a period of feeding, mating occurs and eggs are laid. Previous studies (Duan et al., 1996) indicate that *A. pomorum* has predominantly a nocturnal behavior. This remarkably cold-adapted insect can move, feed, and mate at very low temperatures. As temperature is significantly affecting that behavior it is hard to interpret data of random limb jarring to define if thresholds are reached. If weather conditions are bad, thresholds might not be reached. Or at least, the threshold levels are there but not observed. Optimal monitoring of this pest is hard. Therefore, based on literature data and detailed year-long field monitoring, a prediction model for *A. pomorum* was included in the EVA-OPTIMISE web application by pcfruit.

Control is executed typically on adults in spring before eggs are laid. Once eggs are laid, damage is considered to be done, and when nothing happens, new adults will appear after flowering. Feeding of larvae inside flowers causes the typical hollow capped flowers that will not turn into fruits, or when the larva is killed, turn into a typical deformed fruit. In IPM

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orchards, a second option is to control *A. pomorum* when damage is done, though reducing the number of new adults before they go into aestivohibernation will lower the pressure for next year (Beliën et al., 2020). In organic production systems, management of *A. pomorum* is particularly challenging due to restrictions on insecticides.

Material and Methods

A. pomorum phenology was predicted using a temperature driven model for forecasting dynamics based on detailed year-long monitoring of the development stages in the field and programmed in R software (R Core Team, 2023). We monitored phenology in the region of Sint-Truiden (Belgium), with a radius of about 25 km. First activity (monitored by direct observation and/or limb jarring), first eggs and first egg hatching in flower buds (determined in the laboratory, directly after collecting pierced flower buds in the field), as well as the first pupa and adult in the flowers were assessed since 2010. The results of this monitoring were related to hourly weather data of the Mety-stations in orchards at 10 km maximum distance of the observation site.

Results

This model uses hourly temperatures to predict activity, increased activity, eggs, egg hatching, pupae and adults in the field, with a start date of 01 Jan. Degree days in this article are accumulated above a base temperature of 0°C (DD_0).

Toepfer (2002) already presented a mean of 161+/- 27 DD_0 since January 1 for the initiation of dispersal into apple orchards. The period of highest dispersal speed began when 210+/- 26 DD_0 calculated from January 1 was reached. Expanding on this work, we analyzed 15 years of field observation data on the different life stages of *A. pomorum*, combined with corresponding degree-day calculations based on hourly data from local weather stations (Table 1).

Table 1: Overview on degree-days (DD) since January 1 for the first observation of different life stages of *Anthonomus pomorum* in the field in the region of Haspengouw & Hageland, Belgium (2010-2024).

	first adult out of hibernation	**eggs**	**egg hatching**	**pupa**	**adult**	**egg to adult**
Min	100	236	345	603	825	518
Max	319	410	618	926	1060	726
Mean	**211**	**332**	**481**	**750**	**931**	**599**
SD	62	51	77	74	75	57
Coefficient of variation (%)	29,2	15,3	15,9	9,9	8,0	9,6

In our observations, first observations in the field are recorded at a mean of 211+/- 62 DD_0 since January 1. This observation is rather variable and reveals a minimum of 100 DD_0 and a maximum of 319 DD_0. Further monitoring of successive life stages reveal an egg to adult development time of 599 +/- 57 DD_0. Egg laying starts at 332 +/- 51 DD_0, and egg hatching starts at 481 +/- 77 DD_0. Egg development is estimated to take 149 DD_0. The larval stage takes approximately 269 DD_0 and the pupal stage takes approximately 181 DD_0. The detailed data of all monitored stages are included in Table 2.

The coefficient of variation indicates high variability in first adult emergence compared to egg-to-adult development. Our findings confirm Toepfer's thresholds but reveal higher variability in Belgian orchards. This shows that monitoring is as well time-consuming as susceptible for misinterpretation of the real situation. Therefore we also included data of previous studies to build the model (Duan et al., 1996; Toepfer et al., 2002).

In cold springs, control sprays that are based on adulticidal activity of the active ingredient may be less effective or ineffective because of weevils hiding in refuges. We aim with the model to inform growers both when to control thresholds or when to apply against specific target stages, based on weather data recorded at the trial site and a 14-day weather forecast.

Table 2: Forecasted and observed different life stages of *Anthonomus pomorum* in the field in the region of Haspengouw, Belgium (2025).

location: Haspengouw	**first adult out of hibernation**	**eggs**	**egg hatching**	**pupa**	**adult**
Observed 2025	**28/02/2025**	**10/03/2025**	**31/03/2025**	**22/04/2025**	**2/05/2025**
Predicted – above threshold - 1st observation in 2025	4/03/2025	20/03/2025	4/04/2025	28/04/1995	10/05/2025
Predicted versus observed date:	+4	+10	+4	+6	+8
	MAE = 6,4 days; MSE = 6,81 days; Bias = +6,4 days				
Predicted very 1st observation in 2025	21/02/2025	10/03/2025	27/03/2025	21/04/1995	4/05/2025
Predicted versus observed date:	-7	0	-4	-1	+2
	MAE = 2,8 days; RMSE = 3,74 days, Bias = -2,0 days				

MAE (Mean Absolute Error); RMSE (Root Mean Squared Error)

Discussion

The model provides a reliable decision-support tool for timing control measures against *A. pomorum* in organic and IPM orchards: The outcomes of this study and the implementation thereof in a 14-day forecasting model for *A. pomorum* can support to optimise timing for monitoring as well as controlling this pest.

In 2025, the model predicted the mean first observation 6,4 days too late on average (across stages). This is a systematic positive bias that was consistent across all stages. The very first (under threshold) prediction had in 2025 a small bias and is biologically reasonable. Despite the exceptional winter–spring weather conditions in Haspengouw in 2025, the observed data were very closely in line with the predicted dates. A cold and extremely wet January, followed by a dry, sunny and unusually warm February–April, advanced and accelerated the entire lifecycle of *A. pomorum*.

Treatment performances (efficacy rates) targeting adult weevils highly depend on the presence of the pest, the weather conditions and the number of eggs already present. The model accurately predicts and visualizes phenological stages that are difficult to monitor in the field, which is crucial for the optimal timing of different control measures.

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